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Circulation weather types as a tool in atmospheric, climate, and environmental research

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Classifications of circulation weather systems have a long history in meteorology and climatology. Starting with manual classifications (Hess and Brezowsky, 1952; Lamb, 1972) over specific regions of the globe, these tools (generally called "catalogs of synoptic types") were restricted mainly to weather forecasting and historical climate studies.

In the last decades, the advance of computing resources and the availability of datasets have fostered the development of fast and objective methods that process large amounts of data. Many climatological studies and applications require these data to be as simplified as possible; this is often achieved by analyzing gridded datasets (usually sea level pressure or geopotential height at different levels), and grouping the data into a relatively small number of distinct categories. Since these types are based on meteorological fields observed at a specific instant, they are also called Eulerian classifications.

Several classification methods of circulation weather types have been developed, and are currently used in a wide range of applications (Huth et al., 2008, 2010; Philipp et al., 2010). In addition, in 2002, Sheridan stated that the "Synoptic weather-typing, or the classification of weather conditions or patterns into categories, continues to be popular, and numerous methods have been developed over the past century" (Sheridan, 2002). The increasing interdisciplinary use of circulation weather types in Europe became clear when the European project "Harmonization and Applications of Weather Types Classifications for European Regions—COST733," where a wide range of classification schemes for different spatial domains were developed and compared within the scope of distinct applications. (Huth et al., 2008, 2010; Philipp et al., 2010).

In recent years, the usefulness of circulation weather type classifications has been demonstrated in a large number of scientific domains from climate (Kysely and Domonkos, 2006; Lorenzo et al., 2011), to environmental areas such as air quality (Demuzere et al., 2009) and forest fires (Kassomenos, 2010) or upwelling activity (Ramos et al., 2013). The relationship between circulation weather type classifications and high-impact weather events was also shown in extreme temperature episodes (Kysely, 2008, floods Prudhomme and Genevier, 2011), droughts (Russo et al., 2015), or even lightning activity (Ramos et al., 2011).

Automatic circulation weather type classification algorithms have also allowed exploring the variability of the atmospheric circulation over Europe during the last centuries. This has been possible by using either historical monthly mean grids going back to the eighteenth century (Beck et al., 2007) or daily fields that extend to 1871 in reanalysis products (e.g., Jones et al., 2013), to 1850 in historical data (Philipp et al., 2007) and to 1685 for some weather types (Barriopedro et al., 2014). These studies stress that changes in weather type frequencies can explain an important amount of temperature and precipitation variability. However, one must acknowledge that there are caveats such as non-stationarities in the connection between atmospheric circulation and surface

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climate. In fact, about half of the European surface climate variability (even more on long-term temporal scales) has been related to varying internal properties of some circulation weather types (the so-called within-type variations, e.g., Beck et al., 2007; Jones and Lister, 2009). Recent global warming is also manifesting in additional difficulties, as some studies have noticed a "decoupling" between atmospheric circulation patterns and the surface climate responses since the 1990s (Vautard and Yiou, 2009).

This research topic, "Circulation Weather types as a tool in atmospheric, climate, and environmental research," intends to highlight methodological advances in circulation weather types and also their applications to different research areas. The articles included in this research topic show that circulation weather types can be used not only in Europe, where they have been always more frequent, but also applied to other regions of the world. Therefore, six out of the 10 articles focus on areas outside of Europe, including central and northern America as well as southern Africa. Regarding new methodologies, a circulation type classification based upon Lagrangian air trajectories is proposed by Ramos et al. (2014a). Two different studies highlight the importance of the Lamb circulation weather types (Jenkinson and Collison, 1977) in explaining the precipitation (Ramos et al., 2014b) and drought variability (Russo et al., 2015) over the Iberian Peninsula. An automated version of the Lamb weather type classification and its relationship with precipitation is also applied with success to Saudi Arabia (El Kenawy et al., 2014). Furthermore, Hidalgo et al. (2014) shows that circulation weather types can be used to generate long term near surface climatic time series at high temporal frequencies suitable to force Soil-Vegetation-Atmosphere transfer models. Regarding tropical regions, cold surge activity over the Gulf of Mexico (Pérez et al., 2014) and low level wind regimes over Central America (Sáenz and Durán-Quesada, 2015) are addressed with a circulation weather types approach. Finally, three papers focus on the Southern Hemisphere. Bardossy et al. (2015) explores Fuzzy Rule Based Circulation Patterns to identify different spatial rainfall and ocean wave fields in Southern Africa. Moron et al. (2015) uses a cluster analysis to characterize the variability of circulation weather types across the Maritime Continent. Finally, a synoptic climatology of heavy rain events in the Lake Eyre and Lake Frome catchments is presented by Pook et al. (2014).

During the last few decades, circulation weather type' classifications have been extremely useful to gain insight of the atmospheric processes at the synoptic scale, but also studying the relationship between atmospheric circulation and surface climate variability. As proven in this research topic, the use of circulation weather types' classifications is also becoming frequent to explore climate variability in regions outside Europe. Regarding methodologies, the use of nonlinear methods such as the self-organizing maps (Sheridan and Lee, 2011) is becoming popular, and the introduction of new methodologies, such as the merging weather types and Lagrangian transport presented in the research topic (e.g., Ramos et al., 2014a) is also expected.

Circulation weather types' classifications and their applications will continue to play a fundamental role in characterizing and understanding current and future changes of large-scale circulation and their local impacts in different areas of environmental sciences.

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